National Aeronautics and Space Administration

EXPLORE MARS

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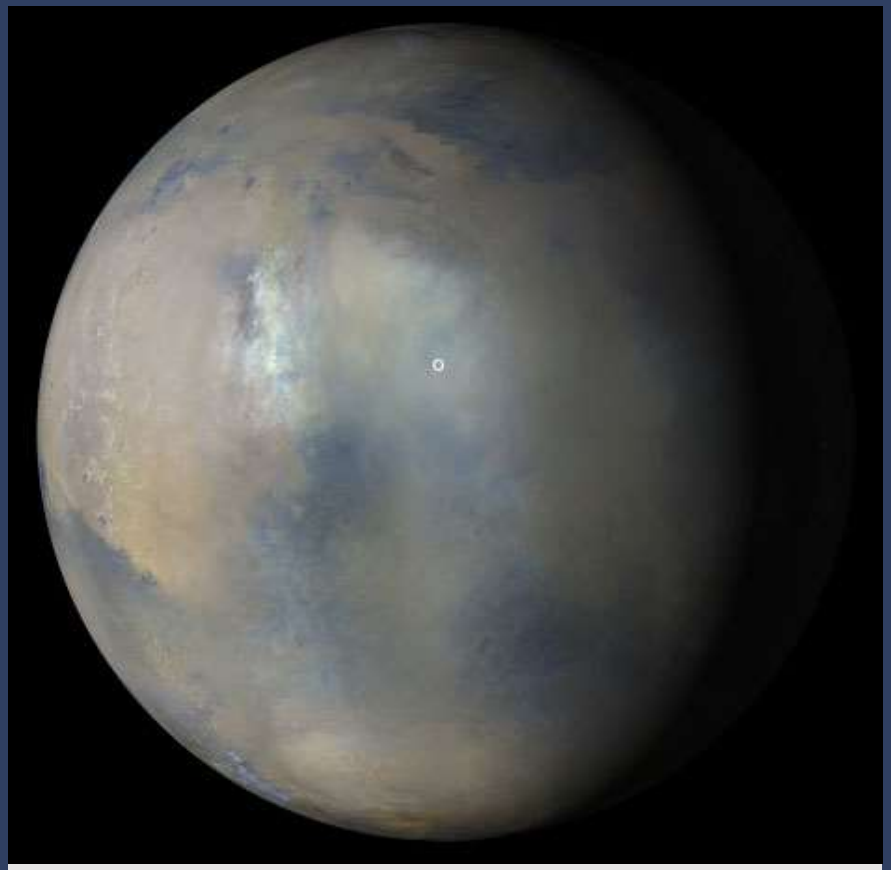
Mars Exploration Program Presentation to MEPAG
February 2, 2022

Mars Exploration Status Highlights

- All Mars assets successfully exited Solar Conjunction ~ Oct 20, 2021
- MEP Program Implementation Review (PIR) held at HQ Oct 18-19, 2021
- Perseverance sample cache has grown to 8 samples (1 witness, 1 atmospheric, 6 cores)
- Ingenuity helicopter successfully performed 18 flights to date, mission ops approved through 2022
- International Mars Ice Mapper Measurement Definition Team (MDT) selected, announced and meetings underway
- Large Martian Dust storm in the new year impacted operations
  - Ingenuity 1st flight of 2022 delayed
  - InSight entered (and exited) safe mode due to decreased power from dust



Multiple images from MRO's Mars Color Imager (MARCI) generated this view of a regional dust storm obscuring Syrtis Major and Jezero Crater (white circle). The images were acquired on Jan. 9, 2022. Credit: NASA/JPL-Caltech/MSSS.

MEP Look-Ahead

2022 Budget

- Awaiting Appropriations Bill
- All MEP missions, including Ingenuity, are funded through the end of fiscal year

Strategic Planning

- MEP off-site held at JPL in Dec 2021
- Creating framework for Strategic Plan in preparation for decadal, including consideration of infrastructure, partnership approaches, outreach and potential science priorities
- Following the release of the Decadal Survey, MEP intends to engage MEPAG in support of strategic planning

Events

- Planetary Mission Senior Review in Feb 2022
- Low-Cost Science Mission Concepts for Mars Exploration Workshop rescheduled to Mar 29-31, 2022 in Pasadena
- Planetary Decadal release anticipated in Mar 2022
- Science Objectives for Human Exploration of Mars Workshop May 4-6, 2022 in Denver

Mission Updates

InSight

- InSight entered safe mode on Jan 7, 2022 due to a severe drop in solar power from a regional dust storm. Insight exited safe mode on Jan 18 as the dust storm abated. Full science operations are expected to resume in 2-3 weeks

MOMA

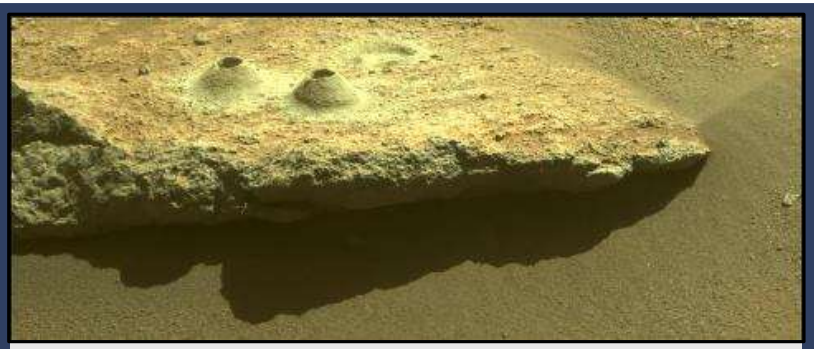
- Instrument fully integrated with Rosalind Franklin rover, integrated rover-level testing continues. NASA supported successful ExoMars Rover parachute drop tests in (Nov 2021). Launch on track for Sept 2022

MEP orbiter missions

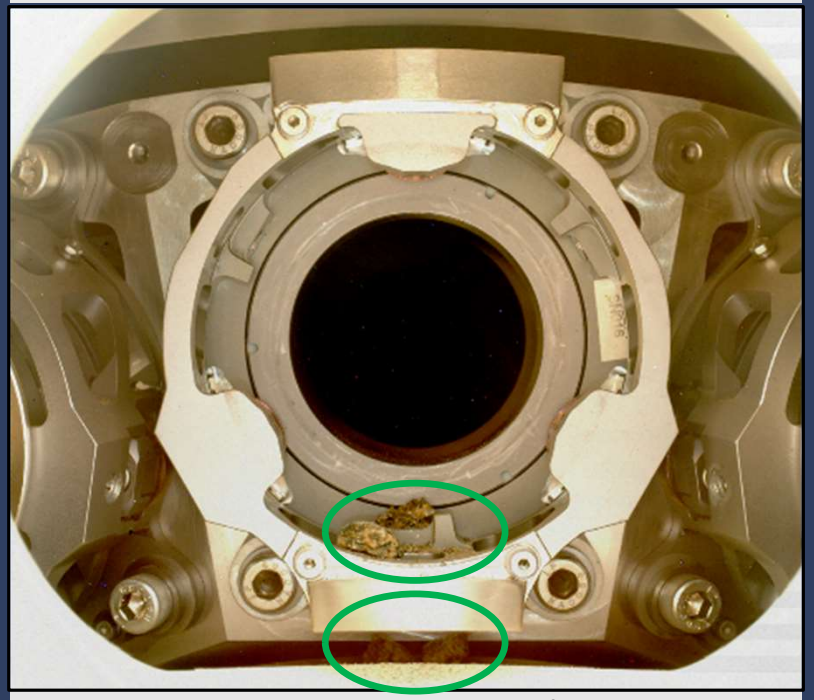
- **Odyssey**: > 20 years since launch, “All-stellar mode” in use to preserve Inertial Measurement Unit (IMU) lifetime; recent fuel estimate projects ~5 more years of spacecraft life
- **MRO**: In nominal science and relay operations; “All-stellar mode” in use to preserve IMU lifetime; providing valuable monitoring data of the current dust events on Mars
- **MAVEN**: In nominal science and relay operations, developing “All-stellar mode” and plan to transition to it in the next few months to preserve IMU lifetime; providing alerts for solar events
- **ExoMars/TGO** (ESA): Continues to return over 55% of the total UHF relay science data from Mars landed assets

Perseverance Sampling

- Perseverance has collected 6 core samples: 2 at Rochette, 2 at Brac and 2 at Issole
  - Bit exchange fault occurred after coring Pauls target from Issole
- Perseverance team successfully demonstrated ability to empty Pauls sample tube on Mars to allow tube reuse after the bit exchange fault
  - Sample tube clearing included 208 seconds of percussion
  - Tube approved and ready for reuse
- Operations team also successfully dislodged obstructions in and below the bit carousel (green circles)
- Article penned by Jennifer Trosper (PM), *Pebbles Before Mountains*, to explain the bit exchange fault recovery approach
- Congrats to the Operations Team for conquering this challenge; Malay now cached!!!



Front Hazcam image of Issole showing the twin tailing mounds at Robine and Pauls . Credits: NASA/JPL-Caltech/MSSS



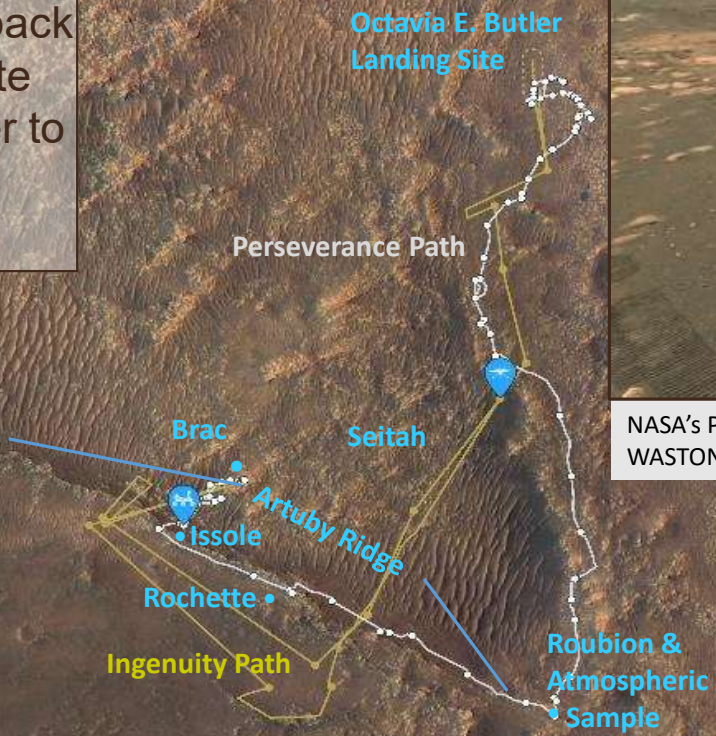
Pebble-sized debris in & below the bit carousel of the Perseverance Mars rover in this Jan 7, 2022, image. Credits: NASA/JPL-Caltech/MSSS

- Ingenuity has now survived more than 330 Martian days and completed 18 flights
- Ingenuity is currently flying back to Octavia Butler Landing Site ahead of Perseverance rover to prepare for a flight software upgrade.

NASA's Perseverance Mars rover took a selfie with Ingenuity using the WASTON camera on the rover's robotic arm Credits:NASA/JPL-Caltech/MSSS

18 flights, over 2.2 mi flown and 33 min aloft

Mars Helicopter Flight 15 - Nav Cam: ground track Credits:NASA/JPL-Caltech



- Performing scouting missions for Perseverance that significantly optimize the exploration of Jezero crater and create valuable time savings in performing Mars science.
- Operations extended through the end of FY 2022.

International Mars Ice Mapper (I-MIM) Status

- Multilateral Concept Team Study underway per the Jan 2021 Statement of Intent among NASA, CSA, ASI, and JAXA
  - Partner agencies completing I-MIM Point Design 2.0 and a preliminary, coordinated mission schedule
  - Netherlands Space Office is an additional active participant in the study, potentially contributing flexible solar arrays
- Reconnaissance*/Science Measurement Definition Team (MDT) Status
  - MDT is defining measurements and recommending optimization for the SAR, providing options for high-priority, synergistic recon/science augmentation and preparing a concept of operations
  - The international team (53 selected members from 12 countries) has begun work with the final report targeted for late Apr 2022 – MDT members include MEPAG stakeholders
    - https://twitter.com/Dr_ThomasZ/status/1458539994591678464

*Reconnaissance: "What we need to know before humans go"

Mars Sample Return (MSR) Campaign

- MSR Science Planning Group-2 report completed and submitted for publication
- Joint MSR Operational Scenarios Definition Team (MOSDT) Report completed
- MSR Campaign Science MOU with ESA in formulation
- First Joint Steering Group (JSG) between MEP and MSR Program held in Jan 2022

Sample Receiving Project (SRP)

- SRP Objectives:
  - Safely secure the samples upon return to Earth
  - Release the samples to the science community as quickly as possible
- SRP making progress on defining project roles and responsibilities
  - JSC will select a Project Manager to lead the effort
- High level plan and schedule for SRP development complete in FY23
- Sample receiving facility Progress
  - Astromaterials Acquisition and Curation Office is reviewing findings of an RFI/Sources Sought, released in Sept 2021, for the SRF
  - MSR facility assessment study structure and scope development underway
  - RFP release to select vendors expected in Spring 2022

Science Updates

- Perseverance science team published its first scientific findings post-landing in *Science*, Oct 2021
- Research paper in *JGR Planets* details how data from Curiosity's RAD shows natural shielding from Martian rock and sediment to protect against space radiation
- Study published in *Proceedings of the National Academy of Sciences* reports on intriguing light carbon isotopic ratios found using TLS and SAM instrument on Curiosity
- InSight detected 4.0 magnitude MarsQuake Dec 24, 2021; longest to-date & 3rd largest
- Current MRO dust storm monitoring revealed dust activity in Nov timeframe not seen since 2008 during those months; provided early warning of InSight power challenge
- MAVEN continues detecting coronal mass ejections and high radiation streams that precede major solar storms to improve the models for predicting Mars solar activity
- Selections complete for Participating Scientists Program on MSL, 25 proposals selected
  - https://nspires.nasaprs.com/external/viewrepositorydocument/cmdocumentid=859816/solicitationId=%7BD8F3461B-7ABD-728A-5B83-6E65B13B2B7D%7D/viewSolicitationDocument=1/Abstracts%20MSLPSP21_BLM[1]_CLEAN.pdf
- Mars Data Analysis Program ROSES 2021
  - Full proposals due in Nov 2021, DAPR review process underway
  - Announcement of selections in late April/early May


EXPLORE
with us

Report of the MSPG2 Study

Planetary Sciences Advisory Committee

Presentation, Nov. 15, 2021

MSR Science Planning Group 2 (MSPG2)[1]

Coordination Team: Gerhard Kminek[1] and Michael Meyer[2] (Co-Chairs), David Beaty[3], Brandi Carrier[3], Tim Haltigin[4], Lindsay Hays[2].

1. European Space Agency, 2. NASA Headquarters, 3. Jet Propulsion Laboratory, California Institute of Technology, 4. Canadian Space Agency

Members[2]: Carl Agee, Henner Busemann, Barbara Cavalazzi, Charles Cockell, Vinciane Debaille, Daniel Glavin, Monica Grady, Ernst Hauber, Aurore Hutzler, Bernard Marty, Francis McCubbin, Lisa Pratt, Aaron Regberg, Alvin Smith, Caroline Smith, Roger Summons, Timothy Swindle, Kimberly Tait, Nicholas Tosca, Arya Udry, Tomohiro Usui, Michael Velbel, Meenakshi Wadhwa, Frances Westall, Maria-Paz Zorzano

1. Members competitively selected through joint NASA-ESA process, 31 members representing 11 countries
2. Terms of Reference signed by ESA and NASA in April 2020; Report complete July 2021

MSPG2 Results

1. Science Management Plan

- Demonstrated the need for an overarching MSR Campaign Science Program and proposed an implementation approach

2. Technical Issues

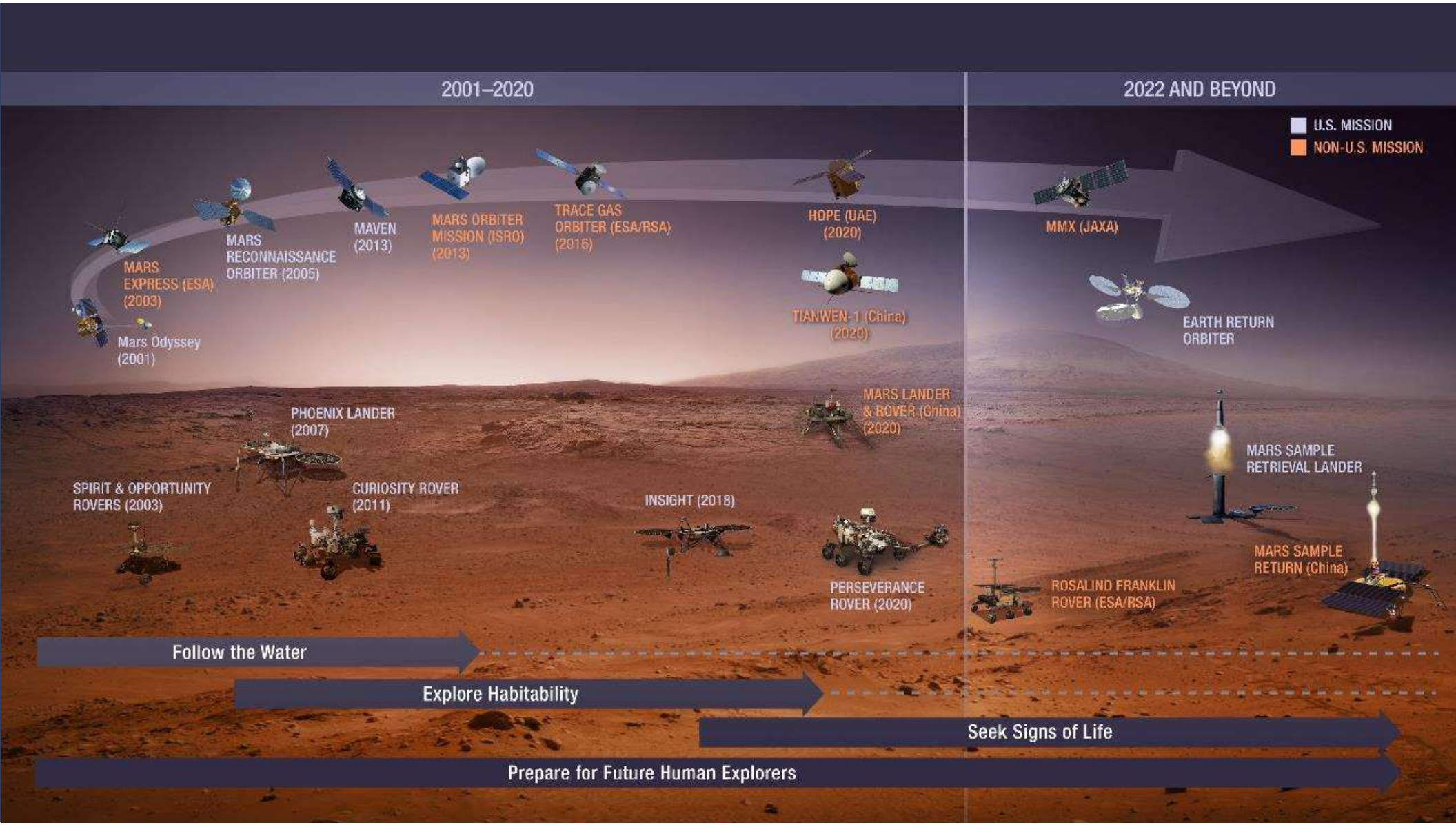
- Established which sample related activities would have to be conducted in the SRF, because they are time-sensitive, sterilization-sensitive, and/or are needed for initial sample characterization

3. SRF Requirements

- Provided technical requirements that would enable the SRF to meet its objectives and accommodate activities that cannot be done in external laboratories

4. Integrated Timeline

- Some aspects are pinned to the left side of the timeline, and others to the right side (i.e. either 2031 or 2033); The MSR Science Program comprises multiple types of activities - some are tied to the sample return date, while others are tied to the planning and activity of the flight missions, and some must start immediately


2001–2020
2022 AND BEYOND
U.S. MISSION
NON-U.S. MISSION
MARS EXPRESS (ESA) (2003)
MARS RECONNAISSANCE ORBITER (2005)
MAVEN (2013)
MARS ORBITER MISSION (ISRO) (2013)
TRACE GAS ORBITER (ESA/RSA) (2016)
HOPE (UAE) (2020)
MMX (JAXA)
Mars Odyssey (2001)
TIANWEN-1 (China) (2020)
EARTH RETURN ORBITER
MARS LANDER & ROVER (China) (2020)
PHOENIX LANDER (2007)
MARS SAMPLE RETRIEVAL LANDER
SPIRIT & OPPORTUNITY ROVERS (2003)
CURIOSITY ROVER (2011)
INSIGHT (2018)
MARS SAMPLE RETURN (China)
PERSEVERANCE ROVER (2020)
ROSALIND FRANKLIN ROVER (ESA/RSA)
Follow the Water
Explore Habitability
Seek Signs of Life
Prepare for Future Human Explorers

Summary of Mars Relay Network (MRN) Assets

Mission	Agency	Launch Year	Orbit	UHF Relay Payload	Max Return-Link Data Rate
ODY 	NASA	2001	385 km x 450 km 93 deg incl	CE-505 redundant units, quadrifilar helix antenna, 12 W transmit power	256 kb/s
MEX 	ESA	2003	298 km x 10,100 km 86 deg incl	Melacom single unit, patch antennas, 8.5 W transmit power	128 kb/s
MRO 	NASA	2005	255 km x 320 km 93 deg incl	Electra redundant units, quadrifilar helix antenna, 5 W transmit power	2048 kb/s adaptive data rate enabled
MAVE 	NASA	2013	~200 km x 4500 km 75 deg incl	Electra single unit, quadrifilar helix antenna, 5 W transmit power	2048 kb/s adaptive data rate enabled
TGO 	ESA	2016	400 km x 400 km 74 deg incl	Electra redundant units, quadrifilar helix antenna, 5 W transmit power	2048 kb/s adaptive data rate enabled

Status of Aging Mars Relay Network Assets

Mission	Mission Status
ODY 	Fuel usage is ~1 kg/yr, with ~5 kg remaining. “All-stellar mode” in use to preserve IMU lifetime. No remaining redundancy in reaction wheel assembly; loss of another wheel would reduce remaining mission lifetime to 1-2 yrs.
MEX 	Some onboard memory issues persist. Fuel load extremely low and uncertain.
MRO 	Fuel usage ~10 kg/yr, with ~160 kg remaining. Battery recently reconditioned to recover state of charge. “All-stellar mode” in use to preserve IMU lifetime. X-band TWTA is effectively single-string due to waveguide transfer switch (WTS) anomaly. Relay services expected to remain viable through late 2020s.
MAVEN 	Fuel usage ~5 kg/yr, with ~74 kg remaining. Fuel usage planned to allow science and relay operations through 2030. “All-stellar mode” in development and plan to transition to it in the next few months to preserve IMU lifetime.
TGO 	Onboard memory issues resolved. Relay services expected to remain viable through 2030.

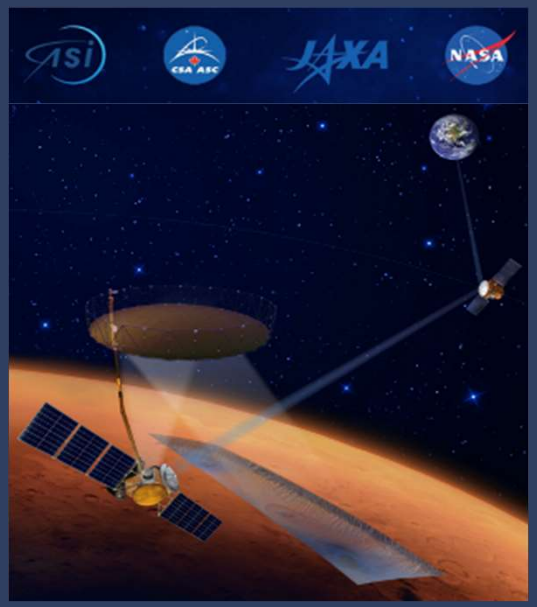
International Mars Ice Mapper (I-MIM) Overview

Opportunity for a Remote-sensing Mission in the Next Decade

Mission contributes to NASA's high priority of enabling human Mars missions

Mapping shallow water ice at mid-latitude locations:

1. Ice Science - sampling ice to answer profound climatology and astrobiology questions
2. Reconnaissance - identify candidate landing sites conducive to find resources to meet human needs (e.g., in situ production of "rocket fuel" for return trip to Earth)



- Supplemental Goal to maximize the mission's return on investment through as much synergistic science as possible (e.g., through near-global near-surface mapping and competitive observations of opportunity, potential relay support for surface missions etc.)
- Synergistic science opportunities meet multilateral science strategies of the partner Agencies and recommendations of the international, multidisiplinary Measurement Definition Team (MDT), drawing on prior studies (e.g., HSO-SAG, NEX-SAG, ICE-SAG etc.)